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ABSTRACT

Gender differences in science interests were examined in two studies of projects entered in a regional science fair in kindergarten through grade 12. A content analysis of 1,319 project topics and materials submitted to the Northeastern Indiana Regional Science and Engineering Fair from 1991 through 1993 showed that girls were more likely than boys to enter projects in biology and less likely to enter projects in physics, with the gender difference in physics smallest at grades K-2 and largest at grades 9-12. It also found that girls and boys tended to use materials re ted to gender-typed interest, such as household products and plants by girls and paper airplanes and electricity by boys. In a second study, interviews with science fair participants revealed no evidence that parents discriminated in topic selection or help with physics or biology projects on the basis of their c ild's gender. (Contains 25 references.) (Author/MDM)

Running head: GENDER DIFFERENCES IN SCIENCE PROJECTS

Gender Differences in Science Interests: An Analysis of Science Fair Projects

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Abstract

Gender differences in science interests were examined in two studies of projects entered in a regional science fair in grades K-12. In the first study, a content analysis of project topics and materials showed that girls were more likely than boys to enter projects in biology and less likely to enter projects in physics, with the gender difference in physics smallest at grades K-2 and largest at grades 9-12. Girls and boys tended to use materials related to gender-typed interests (e.g., household products, plants vs. paper airplanes, electricity). In the second study, interviews with science fair participants revealed no evidence that parents discriminated in topic selection or help with physics vs. biology projects on the basis of child's gender.

Gender Differences in Science Interests:

An Analysis of Science Fair Projects

Gender differences in science course enrollments and achievement, particularly in the area of physics, have raised concerns about gender equity in science education. Females are much less likely than males to enroll in high school physics courses and to pursue higher degrees in the physical sciences (Benbow & Arjmand, 1990; Lubinski & Benbow, 1992; National Science Foundation, 1990; 1992), and show a disadvantage relative to males on tests of physics achievement as early as grades 3 or 4 (Jones, Mullis, Raizen, Weiss, & Weston, 1992; Weiss, Nelson, Boyd, & Hudson, 1989). Gender differences in course enrollment and achievement also exist for biology and chemistry, but are of much smaller magnitude than those for physics. By age 11, girls show a more positive attitude toward biology and chemistry than boys, whereas boys a show greater interest in physical science and geology (Smail & Kelly, 1984; Steinkamp & Mehr, 1984).

Several researchers have argued that the male advantage in physics arises from informal knowledge gained through out-of-school activities (Eccles, 1987; Erickson & Erickson, 1984; Johnson, 1987; Kelly, 1978; 1985; 1987a). Boys report having had more experience than do girls with electricity, tinkering activities (e.g., taking apart mechanical devices and building models), and using scientific tools (Hoffman, 1987; Johnson & Murphy, 1986; Jones et al., 1992; Kahle, Parker Rennie, & Riley, 1993; Kahle & Lakes, 1983; Kelly, 1987b; Rennie, 1987; Sjøberg & Imsen, 1988; Smail & Kelly, 1984). Items on science achievement tests that produce large gender differences are generally related to activities more likely to have been encountered by boys than by girls (e.g., motion of balls, electrical circuits, forces produced by levers, magnetism, and optics); the few items on which girls score better than boys involve knowledge of the human body, nutrition, and bread molds (Bateson & Parsons-Chatman, 1989; Levin, Sabar, & Libman, 1991).

Research on gender differences in science-related activities has focused on children of mid-elementary age or older; relatively little is known of such differences in younger children. Science fair participation, which may involve children as early as kindergarten, provides one context through which to examine the development of gender differences in science-related activities. A previous study of science fair projects at the junior and senior high levels found that females are more likely to conduct projects in the biological sciences and males in the physical sciences (Jones, 1991). The current studies investigated the development of gender differences in science fair projects from kindergarten through high school. The first study used a content analysis of applications submitted to a regional science fair to examine gender differences in research topics and materials. Gender differences in project topics at the early elementary level would indicate that gender differences in science interests are established before much exposure to formal science in school, as has been suggested by Kelly (1978; 1985; 1987a). The second study used interviews with science fair participants to investigate the extent to which parental guidance may be responsible for gender differences in science projects.

Study 1

Method

Materials. The materials analyzed were applications (n = 1319) submitted to the Northeastern Indiana Regional Science and Engineering Fair, 1991 - 1993. Entrants were students in kindergarten through senior high school who had been selected by their home schools. All applications contained the student's name, grade, title of the project, and a statement of the project's objective. In addition, most applications from grades 9-12 were accompanied by a research plan including a statement of the problem and hypothesis, and a description of the methods.

Procedure

Prior to coding, application forms were folded so that the name of the entrant was not visible. Science areas of the projects were coded on the basis of the information contained in the project title, objective, and research plan. The projects were assigned to six categories: behavior, biology, chemistry, earth/space/environment, physics, and other, using a single set of definitions for all grade levels. Percentage of agreement between two coders was 73%, with disagreements resolved by discussion between the coders.

The material serving as the main focus of the project was coded into one of 10 categories: household products, food, paper airplanes/model rockets/other toys, plants, humans/animals/bacteria, electricity/magnets/optics, chemicals/gasses/fluids, environment/weather, building materials/hardware, and other. Initially, two materials were coded for each project, and the two coders were considered to be in agreement if they had chosen the same category for at least one of the two materials; this material was the one then selected for analysis, and disagreements were resolved by discussion. Percentage of agreement was 79%.

Gender of the entrant was coded on the basis of the entrant's first name. Gender was coded as unknown for names considered to be ambiguous (e.g., Jamie or Alex) or unfamiliar. Projects conducted by two partners of the same gender were coded according to that gender; gender was coded as unknown if the partners were of mixed gender or if the gender of at least one partner was ambiguous. The percentage of agreement for gender codings was 98%, with disagreements resolved by consulting books on names for babies. The 87 applications for which gender was coded as unknown were excluded from further analysis.

Results

Data Analysis. Data analysis was conducted using loglinear regression, which allows for the testing of interactions amongst two or more predictor variables with categorical data. Parameter coefficients generated by the loglinear regression were used to determine whether individual cells within an interaction deviated significantly from statistical predictions based on main effects of the relevant variables and any lower-order interactions. The alpha level was set at .05.

Science Area. For the purposes of analysis, grades were arranged into four levels: K-2, 3-5, 6-8, and 9-12. The number of projects in each science area by gender and grade level are shown in Table 1. The difference in number of boys and girls in physics is obvious at each of the grade levels, with a nearly 2 to 1 ratio of boys to girls in grades K-2, and a nearly 10 to 1 ratio in grades 9-12.

A test of the three-way interaction between science area, gender, and grade level showed marginal significance, χ^2 (15) = 24.61, $p < .056$. A significant parameter coefficient for girls in physics in grades K-2 (coefficient = .34, S.E. = .13, Z = 2.61) indicated that, although there were fewer girls than boys in physics at grades K-2, the proportion of girls in physics at this level was significantly greater than at the other grade levels. Likewise, a marginally significant parameter coefficient (coefficient = -.35, S.E. = .18, Z = -1.93, $p <$ .054) indicated that the proportion of girls in grades 9-12 who did physics projects was even lower than at the other grade levels.

The two-way interaction of most interest was that between gender and science area. The proportion of girls compared to boys was significantly greater in biology than in the other science areas (coefficient = .17, S.E. = .06, Z = 2.69), and significantly lower in physics than in other areas (coefficient = -.51, S.E. = .08, Z = -6.58).

Materials Used in Projects. The number of projects using each material is shown in Table 2 by gender and grade level. There was no significant three-way interaction between material, gender, and grade, but the two-way interaction between material and gender was significant, χ^2 (9) = 81.85, $p < .001$. The proportion of girls compared to boys was significantly greater for use of household products (coefficient = .32, S.E. = .11, Z = 2.92), food (coefficient = .35, S.E. = .09, Z = 3.75), plants/molds (coefficient = .31, S.E. = .09, Z = 3.28), animals/bacteria (coefficient = .32, S.E. = .08, Z = 3.90), and chemicals/gasses/fluids (coefficient = .16, S.E. = .08, Z = 2.01). The proportion of girls was significantly less for paper planes/toys (coefficient = -.85, S.E. = .21, Z = -4.10) and electricity/magnets/optics (coefficient = -.39, S.E. = .11, Z = -3.58).

Discussion

The results of this study show that gender differences in science interests are evident in choice of science project topics as early as grades K-2. These results extend previous findings of gender differences in science achievement and interests, which have generally focused on students at grade 3 or above (e.g., Jones et al., 1992; Weiss et al., 1989). Greater male participation in physics projects was evident at all grade levels, although this difference was least pronounced at grades K-2 and most pronounced at grades 9-12. Previous studies have reported an increase in the gap between boys and girls in physics achievement between the ages of 13 and 15 (e.g., Johnson & Murphy, 1986). There was overall greater participation by girls in biology projects; this effect did not change significantly with grade level.

Gender differences were also seen in type of material used in the projects, and these differences did not change significantly with grade level. As found in previous research (Johnson & Murphy, 1986; Jones et al., 1992; Kahle & Lakes, 1983), boys were more likely than girls to use electricity and magnets. They were also more likely to use paper planes and other toys typically considered masculine, such as model rockets, arrows, and balls. Girls, on the other hand, were more likely than boys to use food and household products, plants and animals, and chemicals, gasses, and solutions. With the exception of the latter, these differences in choice of materials appear to reflect gender-typed concerns with "people" versus "objects" (see Eccles, 1987). The fact that such differences were found in projects conducted at home by even thc youngest students supports Kelly's (1978; 1985; 1987a) contention that gender differences in science interests are shaped by influences outside of formal schooling.

Study 2

Jones (1991) has suggested that parental influence may play a role in the selection of different research topics by boys and girls in science fairs. Study 2 examined the role of parents in shaping gender differences in science fair projects by interviewing participants about how they arrived at their topics and who provided help with the projects. It was expected that parents would be reported as more likely to have suggested ideas and provided help with physics projects for boys and with biology projects for girls. It was also predicted that fathers would be reported more likely to have helped with physics projects and mothers with biology projects, reflecting their own areas of interest.

Method

Participants. Participants were students from grades K-12 with projects entered in the 1994 Northeastern Indiana Regional Science and Engineering Fair, who were either available to be interviewed when approached by the interviewer (an attempt was made to interview all science fair participants), or who responded to mailed surveys if they could not be interviewed due to time constraints. Participants who conducted projects in teams of two or more were interviewed as a group; interviews were obtained from a total of 340 individuals or groups. Interviews from two projects conducted by mixed-gender partners were excluded from analysis, resulting in interviews from 161 projects conducted by girls and 177 projects conducted by boys.

Materials. Interview responses were recorded on coding sheets, with space for the participant's gender, grade, title of project, and answers to four questions about how he or she arrived at the idea for their project and help they received with the project. The two questions that were analyzed in this study (each of which was left unanswered by one male participant) were:

1. "How did you get the idea for your science project?" A checklist of answers

was provided, including science book, experience/interest, mother, father, teacher, and other.

2. "Who helped you the most with your project?" A checklist of answers included mother, father, teacher, other person, and nobody.

Procedure. Interviews were conducted by eight undergraduate research assistants and one of the authors. Interviewers approached participants during intervals when they were not being questioned by science fair judges. The interviewers made clear that they were not science fair judges before asking participants if they were willing to be interviewed. Interviews lasted approximately 5-10 min, and began with the youngest students, who were to be dismissed earliest. Due to time constraints, many of the students in grades 7-12 could not be interviewed in person. Interview coding sheets were mailed to these students, with a return rate of 58% (62 of the total number of interviews analyzed were obtained through mailed surveys). In cases of surveys returned from partners on the same project, the earliest response received was chosen for analysis.

Science area of the projects was coded by two research assistants using the applications submitted to the science fair, according to the same criteria as in Study 1. One of the research assistants had previously served as a coder in Study 1. Agreement on science area was 78%.

Results

Because of the relatively small sample size in this study and the focus on gender differences in biology and physics, the science areas were collapsed into three categories: biology, physics, and other areas. Grade levels were collapsed into two levels: grades K-5 and 6-12. Loglinear regression analysis showed no significant three-way interaction between science area, gender, and grade level. The two-way interaction between area and gender was significant, χ^2 (2) = 16.37, $p < .001$. A significantly greater proportion of girls compared to boys conducted projects in biology than in other science areas (coefficient = .26, S.E. = .09, Z = 2.79), and a significantly smaller proportion of girls conducted physics projects (coefficient = -.36, S.E. = .09, Z = -3.88), thus replicating the effects in Study 1.

Origin of Idea. Table 3 shows the origin of ideas for projects by science area, gender. and grade level. It can be seen that most students reported science books or experience/interest as the source of the idea for their projects. There was no significant three-way interaction between origin of idea, science area, and gender, nor was there a significant two-way interaction between gender and origin of idea. There was, however, a marginally significant interaction between science area and origin of idea, χ^2 (10) = 17.33, $p < .07$, with those who had done physics projects, compared to those who had done projects in other areas, more likely to have obtained the idea from a science book (coefficient = .50, S.E. = .17, Z = 2.95).

The three-way interaction between origin of idea, science area, and grade level was significant, χ^2 (10) = 18.54, $p < .05$. Fathers were more likely to be reported as the origin of ideas for biology projects in grades K-5 than in grades 6-12 (coefficient = .93, S.E. = .44, Z = 2.11), and fathers were also less likely to be reported as the origin of ideas for physics projects in grades K-5 than in grades 6-12 (coefficient = -.79, S.E. = .32, Z = -2.44).

Person Who Helped Most. The person reported to provide most help with the project by science area, gender, and grade level is shown in Table 4. It can be seen that mothers and fathers were most often reported to be the main source of help on projects. There was no three-way interaction between gender of participant, science area, and person who helped most with the project, and no significant interaction between gender and person who helped most, although examination of the parameter coefficients revealed that a significantly lower proportion of girls than boys reported fathers to be the main source of help (coefficent = -.23, S.E. = .11, Z = -2.12). There was no significant interaction between science area and person who helped most, although a higher proportion of students doing projects in physics than in other science areas reported fathers as the main source of help (coefficent = .41, S.E. = .19, Z = 2.19).

Discussion

Interviews with science fair participants provided little evidence that parents differentially encouraged their daughters and sons to conduct projects in biology versus physics. There was no indication that parents were more likely to be the source of ideas for physics projects for boys or biology projects for girls. In fact, parents were relatively unlikely to be the source of the idea at all, with the majority of students reporting that they obtained their idea from either a science book or their own experience or interest in the topic. Of course, the possibility remains that parents exerted a subtle influence undetected by their children, for example, by showing more interest when a boy considered a physics as opposed to a biology topic, or more interest when a girl considered a biology as opposed to a physics topic.

There was some evidence indicating that fathers were more likely to help boys than girls with projects, and more likely to help with physics projects than biology or other projects. However, there was no indication that fathers provided more help on physics projects to boys as opposed to girls. Also, it should be noted that fathers were more likely to be the source of ideas for physics projects in older students than in younger students, but were more likely to be the source of biology topics in younger students than in older students.

General Discussion

The findings of both studies show that the biology/physics dichotomy between girls and boys is present in science fair projects, from the early elementary grades through high school. The most striking difference was in physics projects, where there was a noticeably greater number of boys than girls at every grade level. The interview data collected in Study 2 indicates that parents did not overtly suggest topics or provide help in a discriminating way to sons and daughters as a function of the science area of the project. This finding is in accord with the conclusion of Lytton and Romney (1991) that parents in general play very little role in the differential socialization of boys and girls. Instead, gender differences in science projects may stem from the interests, preferences, or skills of the children themselves, perhaps as a result of earlier socialization processes.

Although boys and girls selected different topics for their projects, it should be noted that there was no gender difference in overall rate of science fair participation. Also, there is no reason to suppose that boys and girls were differentially exposed to the scientific method in their projects. The difference in topic selection is of importance because it suggests that the life-long avoidance of physics by girls becomes established at a very young age and appears to increase with formal schooling. The difference between boys and girls in biology projects was not as strong as in physics projects, and apparently does not relate to patterns of course enrollment and employment in the biological sciences, where males and females are nearly equally represented. The underrepresentation of females in the physical sciences may be addressed by providing girls with compensatory experiences in physics-related areas with which they may have had little experience. Kahle et al. (1993) have shown that a unit on electricity conducted by teachers given gender-equity training greatly increased the enjoyment of electricity activities by fourth- and fifth-grade girls, although girls continued to express less confidence than boys with regard to their science ability and ease of the activities. The current findings suggest that such educational intervention may have greater benefits if given at earlier grade levels, when the avoidance of physics-related topics by girls is less pronounced.

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Table 1.
Science Area of Projects by Gender and Grade Level.

Science Area	Grade Level									
	K-2		3-5		6-8		9-12		Totals	
	F	M	F	M	F	M	F	M	F	M
Behavior	3	6	16	7	39	17	7	8	65	38
Biology	18	23	68	31	89	61	28	27	203	142
Chemistry	20	19	34	31	31	26	7	6	92	82
Earth/Space	8	17	21	30	25	12	6	6	60	65
Physics	16	31	29	77	31	65	4	39	80	212
Other	18	13	36	30	48	39	3	6	105	88
Totals	83	109	204	206	263	220	55	92	605	627

Table 2.
Material by Gender and Grade Level

Material	K-2		3-5		6-8		9-12		Totals	
	F	M	F	M	F	M	F	M	F	M
Household Products	2	2	19	14	21	14	7	2	49	32
Food	16	9	27	18	27	10	1	6	71	43
Paper Planes, Toys	1	6	1	13	2	13	1	5	5	37
Plants, Molds	9	9	26	10	26	18	8	9	69	46
Animals, Bacteria	4	8	23	14	60	30	10	11	97	63
Electricity, Magnets, Optics	2	11	10	29	12	20	3	13	27	73
Chemicals, Gasses, Fluids	18	21	35	28	27	23	9	8	89	80

Environment, Weather, Soil	2	5	6	8	6	4	2	3	16	20
Building Materials	3	9	6	10	10	15	0	4	19	38
Other	26	29	51	62	72	73	14	31	163	195
Totals	83	109	204	206	263	220	55	92	605	627

Table 3

Origin of Idea by Science Area, Grade, and Gender

Science Area	Origin of Idea											
	Science Book		Experience/ Interest		Mother		Father		Teacher		Other	
	F	M	F	M	F	M	F	M	F	M	F	M
Biology												
K-5	4	4	2	2	4	2	2	4	0	1	4	2
6-12	4	3	9	5	1	0	0	0	3	1	8	4
Physics												
K-5	7	19	5	8	1	1	1	1	0	3	3	6
6-23	2	4	3	7	0	1	0	4	0	1	2	3
Other Area												
K-5	18	12	18	14	6	10	5	5	4	3	6	4
6-12	9	4	11	19	4	3	2	4	5	4	8	8
Totals	44	46	48	55	16	17	10	18	12	13	31	27

Table 4

Person Who Helped Most by Science Area, Grade, and Gender

Science Area	Help Provider									
	Mother		Father		Teacher		Other Person		Nobody	
	F	M	F	M	F	M	F	M	F	M
Biology										
K-5	8	6	7	7	0	0	1	2	0	0
6-12	9	3	8	4	0	3	5	1	3	1
Physics										
K-5	8	16	9	20	0	0	0	2	0	0
6-23	1	5	1	10	2	1	3	3	0	1
Other Area										
K-5	38	24	16	23	0	0	3	1	0	1
6-12	9	12	10	13	9	6	6	9	5	2
Totals	73	66	51	77	11	10	18	18	8	5